Manipulation of Water Hammer Problem by Modification of NRV Valve

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***Abstract*—Water hammer in piping systems produces large dynamic forces which can damage the pipes and supports. Therefore it is important to minimize the water hammer effects on the piping system. In this work, a new method for the reduction of water hammer by active measures is described- that means the reduction of water hammer by influencing the fluid dynamic conditions of the system. We are concerned with the effects of the rapid valve closures in pipes connected to wave reflection points. The energy is of two kind's Kinetic energy and Elastic energy. Both forms are converted into pressure energy and the rapidity of the conversion is of the utmost importance in terms of ensuring damage that may result. Such energy dissipation in a controlled non damaging way is discussed in this paper. The latest outcomes of the research in this area are also discussed with their failures in the implementation of these concepts in industries, and the feasibility of our new method**

***Keywords*-Water Hammer; Head;Accumulator; Butterfly valve**

I INTRODUCTION

Water hammer is a pressure surge or leave resulting when a fluid in motion is forced to stop or change direction suddenly. The pressure wave may cause major problems from noise and vibration to pipe collapse. By the use of accumulators it is possible to reduce effects of hammer pulses.

II. ENERGY POSSED BY PUMPING OF WATER

The water hammer is a pressure surge or wave caused by the kinetic energy of a fluid in motion when it is caused to stop or change direction suddenly. The movement of liquid mass in a pipe is kinetic energy, which is proportional to the mass of liquid times the square of velocity. For this, most pipe sizing charts recommends keeping the flow velocity at or below 5ft/s (1.5 m/s).

III. EFFECTS OF WATER HAMMER

Quick closing valves, positive displacement pumps and vertical pipe runs can create damaging pressure spikes, leading to blown diaphragms, seals and gaskets also destroyed meters and gauges. Liquid for all practical Purpose is not compressible; any energy that is applied to it is instantly transmitted. This energy becomes dynamic in nature when a force such as quick closing valve or a pump applies velocity to the fluid.

IV. FORMULA TO CALCULATE HAMMERING PRESSURE

By rigid column theory,
When valve closed slowly, the elasticity can be neglected.

$$P = \frac{0.07 * v * l}{t} + P1 \qquad \ldots (1.1)$$

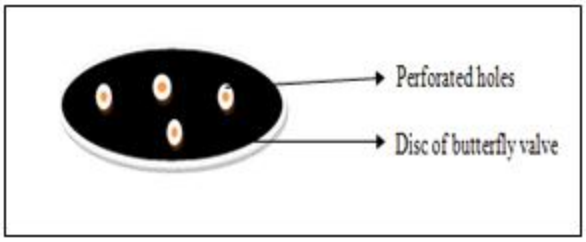
Where, P1= Inlet pressure
t = closing time in seconds
v = flow velocity in ft/s
l = upstream pipe length in feet.

V. OUTCOMES OF RECENT RESEARCH

1. Design a system that minimizes the possibility of water hammer.
2. Locate any undersized pipe and replace it with a larger pipe.
3. Secure loose pipes and to a wall with a pipe damp to try to remedy the problem
4. Wrap some insulation (a towel, an old shirt) around the pipes that are rattling.
5. Install water hammer eliminator if securing the pipes does not solve the problem. It acts like an air chamber or shock absorber and it is added in-line to the plumbing system,
6. A slower acting globe or gate valve will prevent the problem.
7. Accumulator or de-surge can be used.

VI. MODIFICATION SUGGESTED

In a typical non return valve i.e. butterfly valve, the disc which acts as a control element is modified. Here in the disc small holes are to be drilled which acts like the reduction in the pipe diameter. When there is a reduction in the diameter, the energy that is lost by the fluid is high and therefore the adverse effects of hammering action is decreased or highly nullified
The modified disc in a butterfly type non return valve



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VII. ADVANTAGES OF BUTTERFLY VALVE

Butterfly valve posses the following advantages.

1. It can be quickly operated.
2. Suited for large flow of fluids or gases with large amount of suspended solids.
3. The flow element is a disk of approximately the same diameter of the adjoining pipe which rotates on either a vertical or a horizontal axis.

VIII. DECREASE OF HEAD

The energy of the flowing fluid can be decreased by using the concept of pressure drop. The more the contact with the pipe materials the more will be the pressure drop. Formula for the calculation of the main reduction in energy

Head lost due to friction,

$$hf = \frac{4f}{2_i} \quad \ldots (2.1)$$

Head lost due to contraction,

$$hc = \frac{0.5v^2}{2g} \quad \ldots (2.2)$$

We know that by continuity equation,

$$A1v1 = A2v2 \quad \ldots (2.3)$$

Where, A1= original flow area A2= reduction in flow area

$$A2 = \left(\frac{\pi}{4}\right)[D^2 - nd^2] \quad \ldots (2.4)$$

$$A1 = \frac{\pi D^2}{4} \quad \ldots (2.5)$$

D - Original diameter of the pipe
d - diameter of the holes in the disc
n - number of holes in the disc
t - thickness of the disc
Now using continuity equation we get, (2.3)

$$v2 = \frac{v1}{\left[1 - n\left(\frac{d}{D}\right)^2\right]} \quad \ldots (2.6)$$

Now the head lost due to contraction,

$$hc = \left[\frac{\frac{0.5 * v1^2}{\left(1 - n\left(\frac{d}{D}\right)^2\right)^2}}{2g}\right] \quad \ldots (2.7)$$

Therefore the total head lost is given by,

Head lost = $hc + hf + hb$ … (2.8)

$$= \frac{v^2}{2g} * [4fl + 0.375] + \frac{v1^2}{2g\left(1 - n\left(\frac{d}{D}\right)^2\right)} * \left[\frac{0.5}{\left(1 - n\left(\frac{d}{D}\right)^2\right)}\right] \quad \ldots (2.9)$$

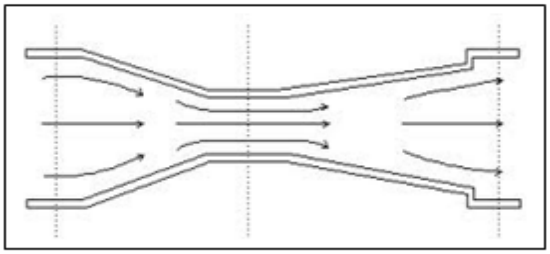
hb- Head lost due to bending

By decreasing the number and the diameter of holes in the disc the energy of the fluid can be reduced. Thus from the above equation it is evident that the energy of the fluid decreases. Also the opposed flow of the fluid decreases the energy of the flowing fluid. Thus the impact of the water hammer problem is adversely reduced

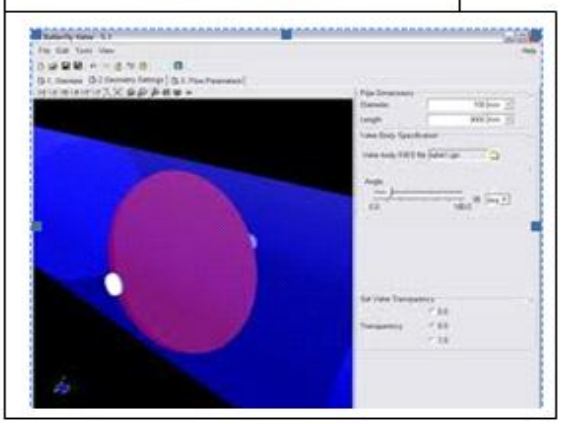
IX. ANALYSIS AND OUTCOME

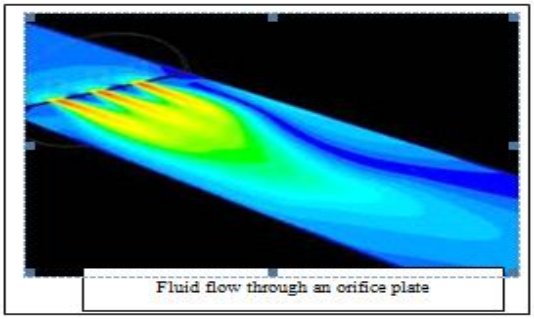
By using the perforation in the disc of a butterfly valve we are able to decrease the energy of the flowing fluid and thereby the impact of the water hammer effect is reduced. Also this method is suitable for chemically active fluids because no opening is provided for the surrounding to interfere with the fluid

The above process can be treated as

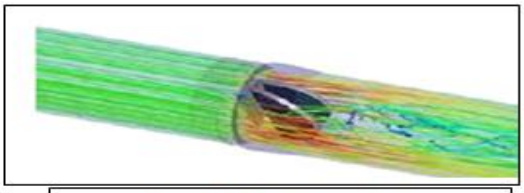


Butterfly valve's disc





Fluid flow through an orifice plate



Fluid Turbulence after the valve

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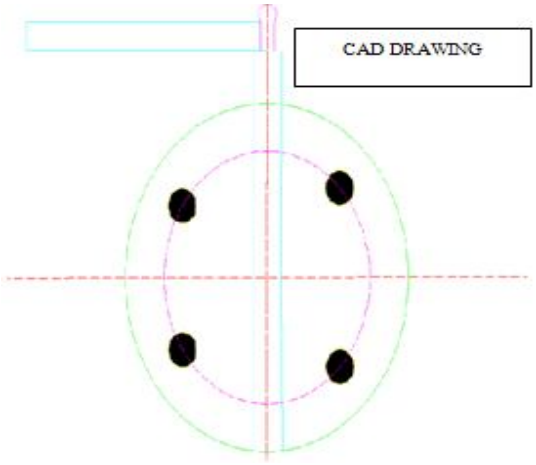


X. CONCEPT BEHIND THE IDEA

According to the law of thermodynamics, Energy can neither be created nor destroyed. But it can be transformed from one form of energy to another form of energy. The energy possessed by pumping of fluid is given by BERNOUILLI'STHEOREM. It says that, in an incompressible flow of fluid, the sum of potential energy, kinetic energy and pressure energy remains constant at any point of its flow.

$$\frac{p}{\rho g} + \frac{v^2}{2g} \quad \ldots (3.1)$$

From the above equation, the datum head (z) remains constant any desired condition of assessment. Hence the two variables that can vary are pressure and kinetic energy. When we consider our setup, it resembles the following path of flow through pipe as the flow in the *ORIFICE PLATE*.

An **orifice plate** is a device used for measuring the rate of fluid flow. It uses the same principle as a Venturi nozzle, namely Bernoulli's principle which states that there is a relationship between the pressure of the fluid and the velocity of the fluid. When the velocity increases, the pressure decreases and vice versa. An orifice plate is a thin plate with a hole in the middle. When the fluid reaches the orifice plate, with the hole in the middle, the fluid is forced to converge to go through the small hole; the point of maximum convergence actually occurs shortly downstream of the physical orifice, at the so-called vena contracta point. Beyond the vena contracta, the fluid expands and the velocity and pressure change once again. Here the modified nrv valve acts like a modified orifice plate, where the pressure head decreases and serves as a flow control element. Thus the flow control is achieved by means of a modified nrv valve – orifice plate.

XI. ACCUMULATOR SETUP

Accumulator is a device that stores potential energy by means of gravity, mechanical springs, or compressed gasses. The stored potential energy in the accumulator is a quick secondary source of fluid power capable of doing useful work as required system. In our setup, a weight loaded accumulator setup is used.

XII. WEIGHT LOADED ACCUMULATOR

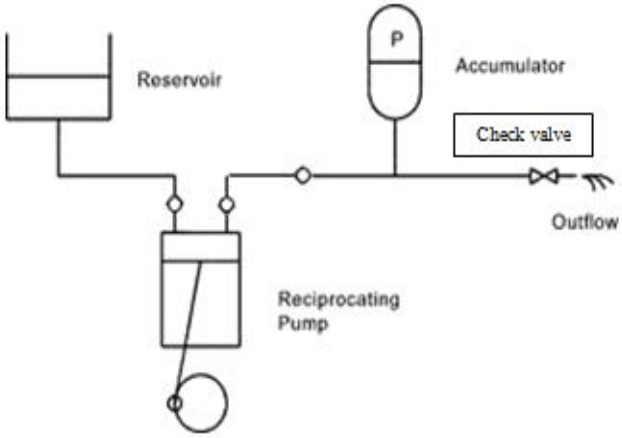
The weight loaded accumulator type consist of a vertical, heavy-wall steel cylinder, which incorporates a piston with packings to prevent leakage. A dead weight is attached to the top of the piston. The force of gravity of the dead weight provides the potential energy of the accumulator. This type of accumulator creates a constant fluid pressure throughout the full volume output of the unit regardless of the rate and quantity of output. The disadvantage of this equipment is that it is unsuitable for mobile equipment.

XIII. SLIDER CRANK MECHANISM

Slider crank mechanism, arrangement of mechanical parts designed to convert straight-line motion to rotary motion, as in a reciprocating piston engine, or to convert rotary motion to straight-line motion, as in a reciprocating piston pump.

XIV. SETUP OF NEW MODEL

The movement of the piston with the pressure raise or decrease of the weight loaded accmlulator due to the increase or decrease of pressure is connected to a slider crank mechanism. The linear motion is converted into rotary motion by this mechanism. This rotary motion is connected to the hand lever of the butterfly valve which also triggers the closing or opening according to the pressssure raise or fall. Thus the overall setup is made.



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XV. CONCLUSION

This method is economically efficient than installing a water hammer arrestor. The effect of water hammer is studied and process of reduction of the energy of the fluid is done. The major pressure surge wave is taken by the accumulator and the slow closing of valve (slider crank mechanism) prevents the rapid closing of valves which practically prevents the causing of water hammer. This saves the adverse effects of the water hammer and protects the valves and pump impellers from damage and making the life of the pipe and pump's impeller to increase.

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